NASA SBIR 2019 Phase I Solicitation

Z3.02 Development of Mobile Welding Capabilities for In-Space Manufacturing

Lead Center: MSFC

Participating Center(s): LaRC, MSFC

Technology Area: TA12 Materials, Structures, Mechanical Systems and Manufacturing

In-Space Manufacturing/In-Space Material Joining

An in-space welding capability is an important supporting technology for the long duration, long endurance space missions NASA will undertake beyond the International Space Station (ISS). Historically structures in space have been assembled using mechanical fastening techniques and modular assembly. Structural designs for crewed habitats, space telescopes, antennas, and solar array reflectors are primarily driven by launch considerations such as payload faring dimensions and vibrational loads experienced during ascent. An in-space material joining capability can potentially eliminate constraints on the system imposed by launch, enabling the construction of larger, more complex and more optimized structures. Welding is an essential complementary capability to large scale additive manufacturing technologies being developed by NASA and commercial partners. Even without volume additive manufacturing, components will eventually need to be mated to larger structures. Welding is also a critical capability for repair scenarios (ex. repair of damage to a structure from micrometeroid impacts). This subtopic seeks innovative engineering solutions to mobilize joining technology for manufacturing in the external space environment, removing the need for large-scale equipment, specialized operators, and large-footprint manufacturing facilities that may not be available on long duration missions. Technologies developed may be infused into NASA missions and should also have high relevance to earth-based manufacturing applications which require fabrication and repair in the field. Note that concepts for mobile friction stir welding are included in Z3 (solid state joining) and should not be proposed to this subtopic. Priority welding process for external in-space use include electron beam, laser beam welding, gas tungsten arc welding, gas metal arc welding, and plasma arc.

Phase I is a feasibility study and laboratory proof of concept of a mobile, robotic welding process and system for external in-space manufacturing applications. Targeted applications for this technology include joining and repair of habitat modules, trusses, solar arrays, and/or antenna reflectors. The Phase I effort should provide a laboratory demonstration of the mobility of the selected welding process and its applicability to aerospace grade metallic materials, focusing on joint configurations which represent the priority in-space welding applications identified above. A proof of concept for repair capabilities in the scenario where structural material is damaged is also desired. Work under Phase I will inform preliminary design of a mobile welding unit and a concept of operations for how the system would be deployed and operate in the space environment, with a focus on specific scenarios: for example, repair of a metal panel following micrometeroid damage, longitudinal joining of two metal curved panels, and joining of a truss to an adjacent truss. The Phase I should also provide an assessment of the proposed mobile unit's operational capabilities (for example: classes of materials which can be welded with the process, joint configurations which can be accommodated, and any expected impacts of the microgravity environment on joint efficiency relative to terrestrial system operation), volume, and power budget. A preliminary design and concept of operations are also deliverables under the Phase I. Concepts for teleoperation of the system should also be

emphasized-- significant astronaut interaction with the system is not anticipated and proposers must have a maturation path toward teleoperation/remote commanding. The proposed system should thus be capable of remote commanding and evolvable to a self-contained free-flying configuration or a system that is externally mounted on a space station platform. Concepts for ancillary technologies such as post-process inspection, in-situ monitoring, or robotic arms for manipulation of structures to be joined may also be included in the Phase I effort.

Phase I requires a demonstration/proof of concept that:

- The process selected can be mobilized in a manner that enables high-value applications of in-space welding for repair and assembly.
- System shows potential for being operated remotely with very little intervention/setup.

Phase II includes finalization of the mobile welding unit design and demonstration of a ground-based prototype system. Phase III would seek to evolve the technology toward a flight demonstration, either via a system mounted externally on ISS, Gateway, or as a free-flyer.

Expected TRL for this project is 3 to 6.

References:

- **â€‹â€‹â€‹â€‹â€‹â€‹â€‹â€‹** Paton, Boris EvgenÊ¹evich, and V. F. LapchinskiÄ. Welding in space and related technologies. Cambridge International Science Publishing, 1997.
- Tamir, David, et al. "In-Space Welding: Visions and Realities." (1993).
- Prater, T., N. Werkheiser, and F. Ledbetter. "Toward a Multimaterial Fabrication Laboratory: In-Space Manufacturing as an Enabling Technology for Long Duration Spaceflight." Journal of the British Interplanetary Society (2018).